

Genetic Control of Melanism in *Panthea furcilla* (Packard) (Lepidoptera: Noctuidae)

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Abstract: The history of melanism in *Panthea furcilla*, and methods for rearing and mating this moth are presented. Based on rearing data of *P. furcilla* it is tentatively concluded that melanism in *P. furcilla* is controlled by a single, sex-linked, dominant gene.

The phenomenon of industrial melanism in the Lepidoptera has been noted and studied since the turn of the century. Briefly, the term industrial melanism refers to the spread of black or dark forms of normally light-colored, cryptic moths in areas subject to industrial pollution. Study of this process has taken place primarily in the British Isles (reviews in Kettlewell, 1961; Ford, 1964). Although this phenomenon is not rare in America, it has received little attention here. Owen (1961, 1962) and Sargent (1971) both make the point that further study of industrial melanism in America is needed.

One American moth which has been studied is *P. furcilla* (Packard) (Lepidoptera, Noctuidae). Klots (1964, 1966, 1968) has done some light trapping of wild adults and some rearing studies on this species and has devised a tentative scheme of inheritance of melanism in *P. furcilla*.

HISTORY

P. furcilla is, in the broad sense, a legitimate industrial melanic. The melanic form of *P. furcilla* (*atrescens*, McDunnough), first described from a specimen taken at Norway Bay, Quebec, Canada, on July 16, 1937 (McDunnough, 1942), makes up substantial portions of at least two populations in New England (Klots, 1964, 1966, 1968b; Sargent, personal communication).

BACKGROUND OF THE PRESENT STUDY

P. furcilla is an excellent subject for rearing studies on melanism for several reasons. First, the melanic and typical forms of *P. furcilla* are distinct (see plate 1). The life history of *P. furcilla* also makes it a good organism for research of this type. The caterpillar feeds primarily on white pine, *Pinus strobus* (L.),

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Plate 1. *Panthea furcilla* Typical (L.) Melanics (R.) Males (Top) Females (Bottom)

a feeding habit that insures a food supply of year around availability. This is important, since caterpillars of *P. furcilla* that are kept at high temperature and on a long photoperiod, show no diapause. The species is, in this area, bivoltine, so wild adults are available twice each summer, in June, and in August. Also, *P. furcilla* is common in the Amherst area so breeding stock is easily obtained.

All wild-caught moths used in this experiment were collected at lights, in Leverett, Massachusetts. The white pine used in this study was also from Leverett. Leverett is located about 25 air miles north of Springfield, 75 air miles west of Boston and 66 air miles east of Albany, New York. The area apparently receives little air-borne pollution. Lichens are common on trees and rocks, and the environment shows no visible darkening by soot or other air pollution fallout. The population of *P. furcilla* in Leverett is, however, approximately 50% melanic (Sargent, personal communication).

Rearings in this study were conducted on branches of white pine contained in water-filled gallon milk jugs. These were placed in screen cylinders 36" high by 22" in diameter, with a screen lid. A 1" thick layer of pine needles was put in the bottom of the cage as a place for the caterpillars to pupate. Rearing conditions of 85–95% relative humidity, 70–75°F, and a photoperiod of 16 hours light/8 hours dark gave best results. Under these conditions survival was almost 50% from eggs to adult in the case of rearing I-M.

In the case of laboratory matings the system which met with the most success was as follows:

Late in the afternoon a recently emerged male and female were placed in a mating cage consisting of a screen cylinder 18" high and 9" in diameter, with sheets of cardboard for top and bottom. A small branch of white pine was also

put in the cage. This arrangement was then left alone for 72 hours. At the end of this period male, female, and eggs, if any, were removed. Approximately 60% fertile matings resulted.

RESULTS OF REARINGS

Group I-M was reared from 184 eggs obtained from a wild caught melanic female. The results were as follows:

Typical male ($T\delta$), 0; Typical female ($T\eta$), 45; Melanic male ($M\delta$), 39; Melanic female ($M\eta$), 0; Total, 84.

Group I-N was reared from 200 eggs from the mating of a typical female and a typical male. The results were as follows: $T\delta$, 45; $T\eta$, 48; $M\delta$, 0; $M\eta$, 0; Total, 93.

Group II-3 was reared from 126 eggs from a mating of a melanic male and typical female, both from group I-M. The results were as follows: $T\delta$, 14; $T\eta$, 11; $M\delta$, 9; $M\eta$, 14; Total, 48.

Group II-5 was reared from 93 eggs resulting from a mating of a typical female from group I-M and a typical male from group I-N. The results were as follows: $T\delta$, 13; $T\eta$, 13; $M\delta$, 0; $M\eta$, 0; Total 26.

DISCUSSION

The results of rearing I-M and II-3 make a strong case for the control of melanism in *P. fuscilla* by a single, sex-linked, dominant gene. Group I-M yielded all typical females and melanic males. Two hypotheses may explain the results of rearing I-M, that of melanism being controlled by a sex-linked dominant and that of melanism being sex-limited. The eggs in rearing I-M were obtained from a melanic female so the second hypothesis must be rejected, leaving sex-linked dominance as the only possibility. In moths, females are XY and males XX, therefore the female in question must have mated with a typical male. The males in group I-M must have been heterozygous with respect to melanism. If one then crossed a melanic male from group I-M with a typical female one would expect a 1:1:1:1 ratio, typical males to typical females to melanic males to melanic females. Rearing II-3 represents such a cross, and the results do not differ significantly from those expected. ($\chi^2 = 1.78$, $P > .50$.) Table 1, which compares the results of rearing I-M with expected ratios assuming different types of inheritance, shows that sex-linked dominance is the only explanation to which the observed results conform.

Table 2 contains the results of my experimental rearings, all of Klots' rearings in which phenotype and sex of individuals were given (and which gave somewhat odd results) and one rearing by Sargent. These results are also compared with the results expected assuming melanism to be a sex-linked dominant and chi-square values based on this comparison are given. Rearing I-S (Sargent, unpublished)

TABLE 1. A comparison of the results of rearing I-M with expected results assuming different types of inheritance.

Observed results of rearing I-M					
T ♂ :0	T ♀ :45	M ♂ :39	M ♀ :0		
Expected results assuming different types of inheritance					
Types of Inheritance	Mating*	Numbers of Moths			
		T ♂	T ♀	M ♂	M ♀
Sex-linked dominant	M ♀ × T ♂	0	42	42	0
Sex-linked recessive	M ♀ × T ♂ ht	21	21	21	21
Sex-linked recessive	M ♀ × M ♂	0	0	42	42
Autosomal dominant	M ♀ ht × M ♂ ht	10.5	10.5	10.5	10.5
Autosomal recessive	M ♀ × T ♂ ht	21	21	21	21

*—Genotypes of all males assumed
ht—heterozygous

and rearings K-Pf M-1 and K-Pf Ms-2 (Klots 1968) all were from eggs obtained from wild caught melanic females. If one assumes that these females had mated with heterozygous melanic males, and that melanism is controlled by a sex-linked dominant gene, the cross can then be expressed, calling melanic M and typical m, MY × Mm. This cross is diagrammed as follows:

	M	m
M	MM	Mm
Y	MY	mY

Thus a ratio of 1:2:1, melanic females to melanic males to typical females, would be expected. None of the results obtained differ significantly from this, (see Table 2). Only one rearing cited, K-Pf 7 (Klots, 1968), a mating of a typi-

TABLE 2. Results of various rearings compared with results expected, assuming sex-linked dominance.

Rearing	Numbers of Moths								χ ²	P
	Observed				Expected					
	T ♂	T ♀	M ♂	M ♀	T ♂	T ♀	M ♂	M ♀		
I-M	—	45	39	—	—	42	42	—	.43	>.50
II-3	14	10	9	14	11.75	11.75	11.75	11.75	1.77	>.50
K-Pf M-1 ¹	—	11	5	—	—	8	8	—	2.24	>.10
K-Pf M-1 ²	—	15	27	16	—	14.5	29	14.5	.32	>.80
K-Pf Ms-2 ²	—	4	6	7	—	4.25	8.5	4.25	2.25	>.20
K-Pf (7) ²	—	3	4	1	2	2	2	2	*	*
I-S ³	—	3	8	3	—	3.5	7	3.5	*	*

* Sample size too small to apply chi-square

cal female and a melanic male, gives results different from those expected. But the sample size was not large enough to make this difference significant. The conclusion that melanism in *P. furcilla* is primarily controlled by a sex-linked dominant does not agree wholly with Klots' (1968) hypothesis on the nature of inheritance of melanism in *P. furcilla*. Klots says that melanism is dominant, but not completely so. He also says that melanism in *P. furcilla* is probably controlled by two genes, one which produces the phenotype "wholly melanic" and another which produces the phenotype "very strongly melanistic." He further states that these two phenotypes show no inter-gradation. Klots (1968) also reports, in his wild caught samples, a class, comprising some 18% of the population, which is "slightly to strongly melanistic." In looking at Klots' data one notices that this category is absent from all rearings, with the exception of some slightly melanistic individuals reported in the 1966 paper. In this report Klots makes repeated reference to pupal mortality during "hibernation." From this reference one might surmise that the pupae were kept in a cold place. It has been noted that low temperatures administered to moth pupae can cause darkening in the adult (Merrifield, 1890, 1891; Kettlewell, 1943). This then may be the origin of Klots' slightly melanistic individuals. Since I have not seen Klots' wild-caught series, I cannot comment further on this.

The other problem which Klots' data present is the mutually exclusive wholly melanic and very strongly melanistic categories. The melanic *P. furcilla* I have seen are not easily assigned to exclusive categories. Some are a bit darker than others, especially in the males. This would seem to suggest a possibility of some degree of incomplete dominance. Two of Klots' rearings, K-Pf M-1 (1966) and K-Pf M-1 (1968), involve "wholly melanic" females, but K-Pf Ms-2 is from a "very strongly melanistic" female, and while this last sample is a bit small, they all fit the hypothesis of melanism being a sex-linked dominant. While there may be modifiers or environmental factors at work which make melanics lighter or darker, it must be said that on the basis of present data that melanism in *P. furcilla* seems predominantly under the control of a single sex-linked dominant gene.

Certainly the genetics of melanism in many species, including *P. furcilla*, deserves further study, as does the phenomenon of industrial melanism itself.

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